BARBER COLMAN

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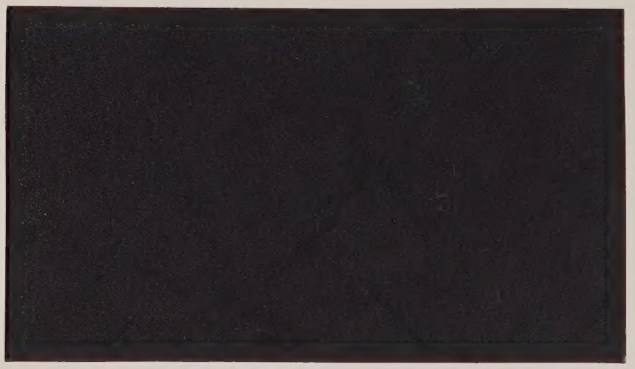
IN 5-1

MODEL 475P CAPACITROL

INSTRUCTION MANUAL

BARBER-COLMAN COMPANY
Industrial Instruments Div. • Rockford, Ill., U.S.A.



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MODEL 475P CAPACITROL

INTRODUCTION

This instruction manual is designed to help you secure maximum benefits from your new Series 470 Capacitrol. It should be given to persons responsible for installation, operation and maintenance of this instrument.

Your Barber-Colman factory trained field engineer is always available for further help in the solution of your control problems. Offices are located in all principal cities.

BARBER-COLMAN COMPANY
Industrial Instruments Division

Litho in U.S.A.

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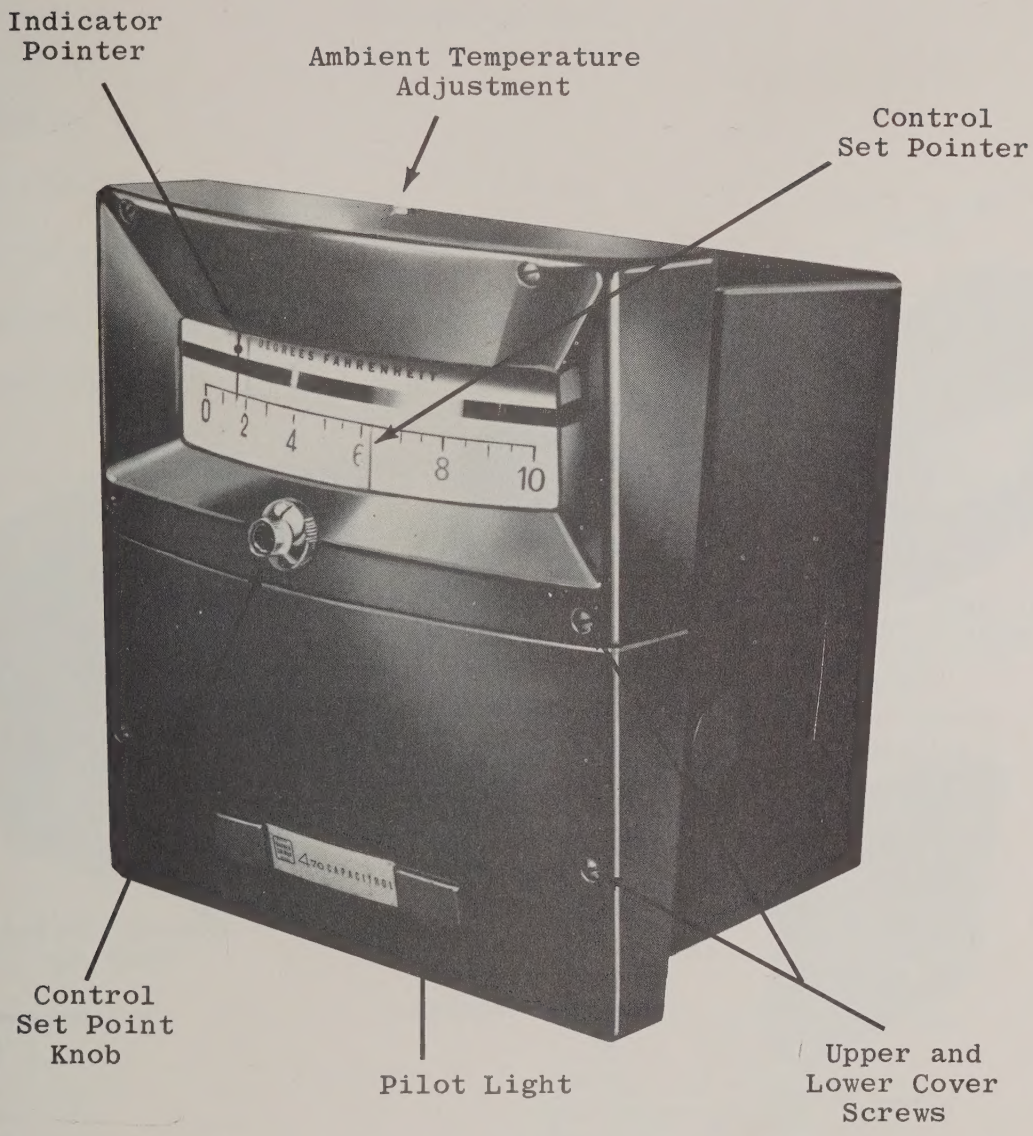
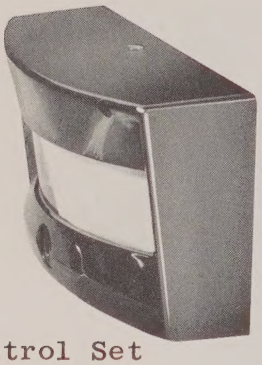
TABLE OF CONTENTS

	Page
Illustrations	i
Specifications	iii
Description	
General Description	1
Description of Electronic Circuit	11
Installation and Start-Up	
Unpacking the Instrument	3
Mounting Instructions	3
Power Wiring	3
Mounting Dimensions	4
External Wiring Diagrams	5
Meter Shunt Wire	6
Thermocouple Wiring	6
Thermocouple Break Protection	7
Thermocouple and Leadwire Resistance Compensation	10
Cold Junction Compensation	10
Operation	
Control Action	13
Control Adjustments	13
Proportional Band	13
Manual Reset	13
Start-Up Adjustments	13
Maintenance	
Routine Servicing	15
Measurement or Control Trouble	15
Calibration Check	16
Internal Wiring Diagrams	18
Replacement Parts List	20
Suggested Repair Parts	21
Definition of Terms	22

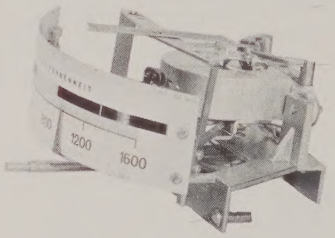


MODEL 475P CAPACITROL

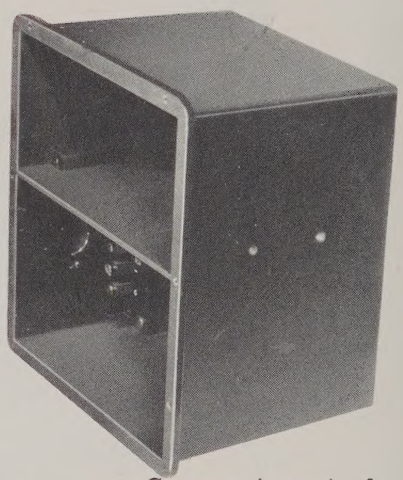
Upper Front Cover



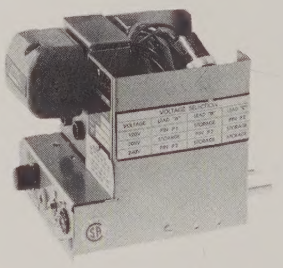
Indicating Meter



Control Set Point Knob



Compartmented Housing



Control Chassis

Lower Front Cover

MODEL 475P

MAJOR COMPONENTS

SPECIFICATIONS

Meter

Scale Length	6 inches
Minimum Span	9 mv or 0-300°F - Type J
Calibrated Accuracy	± 1/2% of full scale
Sensitivity	50 microamps for full scale deflection (nominal)
Internal Resistance	20 ohms per millivolt (nominal)
External Resistance	a) As standard, calibrated for 15 ohms and supplied with replaceable compensator to make up difference between calibrated resistance and actual value of external resistance. May be calibrated for other values of external resistance if required. b) Units with bridge type TCB are adjustable for external resistances up to 20 ohms
Compensation	a) Automatic cold junction temperature compensation -- mechanical standard; electrical optional. Range 40 to 130°F b) Copper coefficient compensation. Range 40 to 130°F
Thermocouple Break Protection	Standard type TCB furnished unless otherwise specified. Bridge type TCB available

Chassis

Control Action	Proportional position control
Proportional Band	Adjustable from 0.5% to 5% of full scale
Control Adjustment	External control set point knob adjustable over 100% of scale. Reset and proportional band adjustable
Power Requirements	12 volt amperes
Electronic Tube	Standard 12AU7
Power Supply	Interchangeable: 120, 208, 240 volts a-c, 50 - 60 cycle

Dimensions and Weights

Overall Dimensions	9 15/16" H x 9 5/8" D x 9" W
Cutout for Flush Mounting	8 3/16" W x 9 3/16" D NOTE: Meter housing will extend approximately 6" into panel when flush mounted
Net Weight	Approximately 16 pounds
Shipping Weight	Approximately 23 pounds

MATERIAL WARRANTY

All equipment except tubes, photocells, and thermocouples, which within one year from date of shipment is found to have been originally defective, will be repaired (replaced if necessary) free of charge, if returned immediately, prepaid, to the factory at Rockford, Illinois.

DESCRIPTION

General Description

The Model 475P Capacitrol is a millivoltmeter-type indicating controller providing proportional position control through a Barber-Colman reversible motor operator (power unit). The motor operator can be linked to a valve, damper, rheostat or other device to change the fuel input to the process in an amount proportional to the deviation of the indicating pointer from the control set point. Through the use of a modified bridge type circuit and a polarized relay, a change in temperature will drive the motor operator in a direction to restore balance and return the process to the control set point value. Applications for this system are the proportional temperature control of heat treating furnaces, kilns, drying ovens, galvanizing baths and the like.

The proportional band of the Model 475P is adjustable from 0.5% to 5% of full scale. An adjustment knob, for this purpose, is located on the front of the control chassis accessible by removing the lower front cover of the meter. A manual reset adjustment is also provided on the front of the control chassis. The control chassis is of the plug-in type to facilitate interchange or servicing.

The control set point setting knob is located just below the instrument scale. It is easily adjusted but designed to protect against accidental shifting. A signal light indicates when the instrument is powered.

Description of Electronic Circuit

The Model 475P is a development of an original "electronic link" design. A small vane or flag, suspended from the indicating pointer, passes between two flat coils mounted on the control set point arm. Depending on the position of the vane in the coils, the output of an oscillator circuit will vary. This varying output is then fed to an electronic polarized relay. The signal impressed unbalances the relay to make the control contacts within it energize either the forward or reverse field (as the case may be) of a reversible motor operator or power unit.

Rotation of the motor operator will be in a direction such that the feed-back from a rebalancing slidewire (mechanically linked to the output shaft of the motor operator) will strive to balance the oscillator signal. Rotation will continue until electrical balance is restored. At this time the motor operator position will be directly proportioned to the deviation of the instrument indicating pointer with respect to the control set point.

An adjustment is provided in the tank portion of the instrument oscillator which changes the slope of the oscillator output curve to provide an effective means of changing the width of the proportioning band. Corrections for offset can be made by means of an alignment or turning adjustment.

Unpacking the Instrument

This precision instrument and its associated equipment have been carefully manufactured and packed at the factory. Remove the instrument and accessories from the packing box and check items against the packing slip. If the equipment is found to be damaged in transit, report damages to the carrier immediately. Repack in original packing box until ready for installation.

CAUTION:

Handle with care.
Safeguard instrument from shock before and after installation.
Avoid oil accumulation and exposure to moisture.
Keep instrument temperature under 130°F and over 40°F.

Mounting Instructions

Locate instrument to avoid excessive vibration, shock and temperatures outside the range of 40°F to 130°F. Avoid furnace walls, radiation of heat, machine frames and outside walls. Provide suitable shelter against moisture and temperature extremes if installed outdoors. Refer to appropriate drawing for mounting details.

Power Wiring

The instrument is wired for 120 volts a-c. If available power supply is other than this, the proper voltage can be selected as follows:

The lower front cover should be removed by loosening the two screws. The chassis assembly can then be removed by firmly pulling forward. A voltage selection board is located on the top left side of the chassis. The voltage can easily be changed by plugging the wires onto the proper pins as shown on the right side of the chassis enclosure and as illustrated in Figure 1.

The two marked pins #1 and #2 are used for the voltage range desired while the other pins are used for storing the unused wires. The wires are marked A, B and C. The connections are as shown below:

VOLTAGE SELECTION

Voltage	Lead "A"	Lead "B"	Lead "C"
120 v	Pin #1	Storage	Pin #2
208 v	Storage	Pin #2	Storage
240 v	Pin #2	Storage	Storage

Figure 1

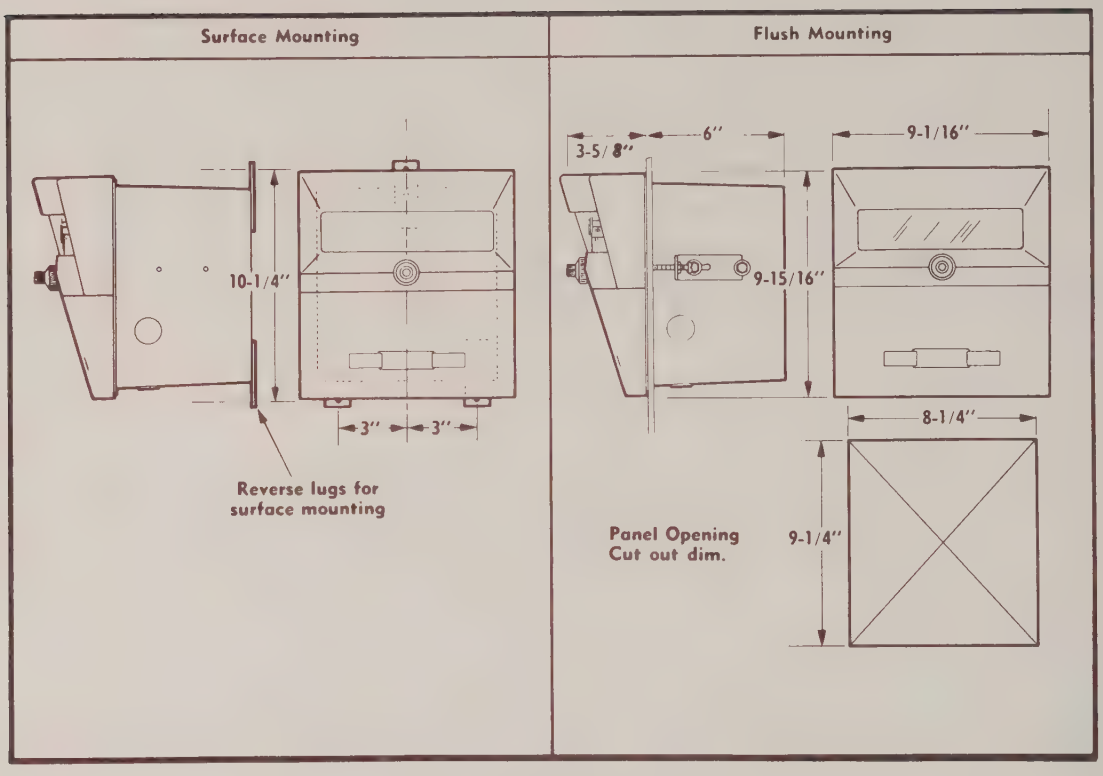


Figure 2
Mounting Dimensions
(Rigid Mounting)

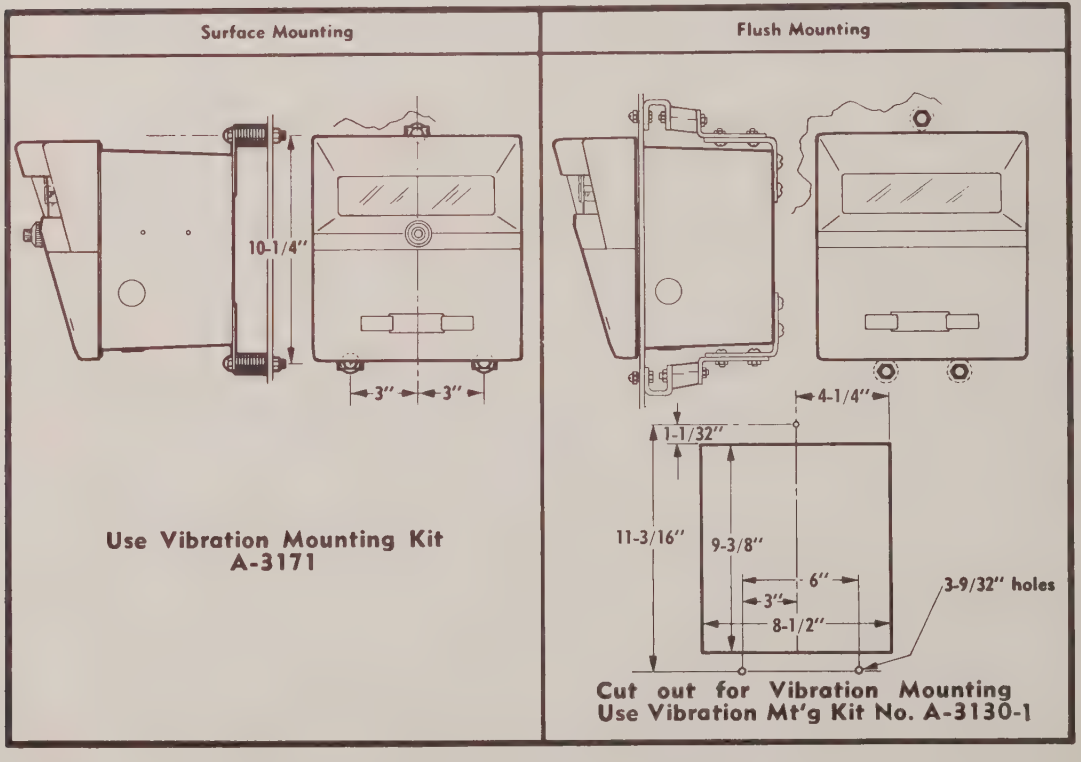
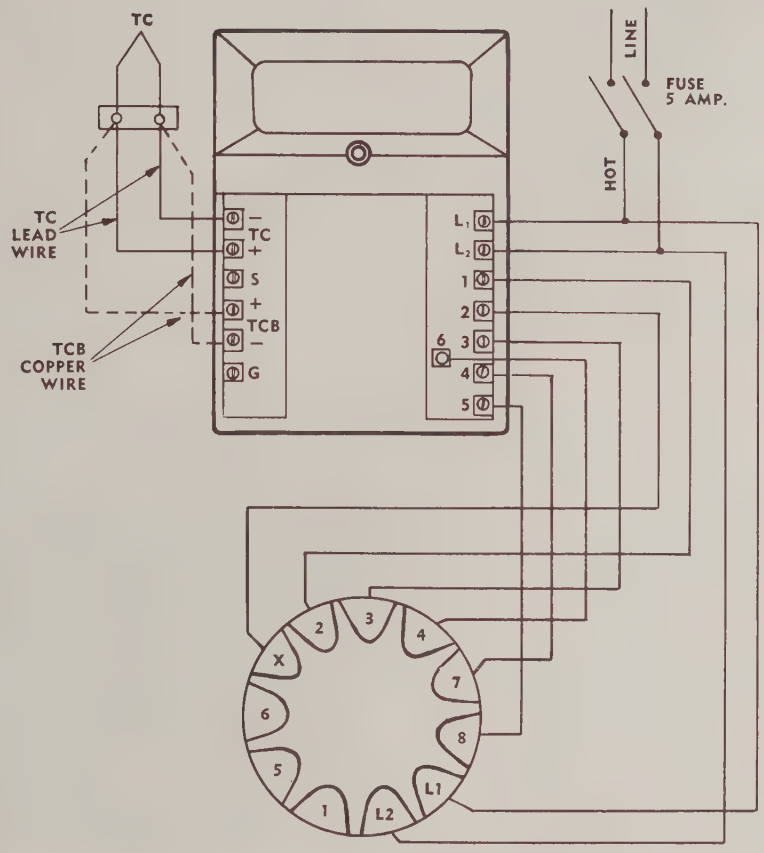


Figure 3
Mounting Dimensions
(Vibration Mounting)



Model 475P Indicating Controller and Barber-Colman proportioning type Motor Operator wired for counterclockwise rotation to increase heat input.

For clockwise rotation to increase heat input, interchange connections at terminals 1 and 3 and interchange 4 and 5 at the terminal strip of the Model 475P.

Caution: Do not use a Motor Operator with a built-in transformer.

Figure 4

External Wiring Diagram

After the proper voltage has been selected and the chassis replaced the instrument is then ready for wiring. The instrument will operate on both 50 and 60 cycle a-c systems. The desired a-c supply voltage is connected to terminals L1 and L2 inside the lower compartment. If the instrument is equipped for back wiring, remove the back panel to expose the terminal strips. All wiring should be in accordance with the applicable electrical codes. Where maximum protection of the instrument is desired a 1/8 ampere slow blow fuse may be added in the power line to the instrument.

Solid wire is recommended for instrument wiring. If stranded wire is used, tin the ends to provide secure connections.

The instrument should be grounded. This is accomplished by attaching the ground terminal (G) directly to a good ground, such as a cold water pipe.

CAUTION: Do not connect the ground terminal to the neutral a-c line.

Meter Shunt Wire

After the instrument is installed, disconnect the jumper wire across terminals marked "Shunt", "TC-" and "TC+". This wire is used to shunt or dampen the meter movement for protection during shipping, handling and installing the instrument, but should be removed for normal operation. Replace the shunt wire when handling or reshipping the instrument and position the red control set pointer fully upscale.

If the meter assembly is removed from the case, an automatic shunt device protects the meter assembly from damage. Other shunt wiring is not required.

Thermocouple Wiring

Do not run thermocouple leadwire with other power or control wiring. However, several thermocouple leadwires may be run in the same conduit if desired.

Use only extension leadwire correct for the type of thermocouple (TC) as specified on the scale. Except for certain radiation detectors, ordinary copper wire cannot be used. The types of sensing elements most commonly specified are:

Iron-Constantan	Type J
Chromel-Alumel	Type K
Platinum-Platinum 10% Rhodium	Type S
Platinum-Platinum 13% Rhodium	Type R
Heat-Eye Radiation Pyrometer	- - -

See Barber-Colman Thermocouple Catalog for a full selection of thermocouple assemblies and extension leadwire.

Proper polarity (+) and (-) of the leadwire must be observed to obtain correct readings. The negative wire is usually coded red. Correct polarity of the leadwire can be checked by forming a temporary junction at the far end, heating this junction with a match, and noting the deflection of the meter indicator. An upscale deflection is proof of correct polarity of the leadwire.

The thermocouple should then be connected to the leadwire and the indicating pointer should again deflect upscale when the thermocouple hot junction is heated. If the indicator moves downscale, reverse only the thermocouple connections at the terminal block since the leadwire has already been correctly connected to the instrument.

Secure the leadwires firmly under the terminal screws. If desired, spade lugs may be used.

Thermocouple Break Protection (TCB)

Each instrument is equipped with thermocouple break protection (TCB). If a break in the thermocouple circuit occurs, the meter indicator will be driven upscale past the control set point, causing the power to the controlled load or process to be turned off and guarding against overheating when an open thermocouple circuit occurs.

Two systems of thermocouple break protection are used. Standard models of the instrument are provided with a small d-c voltage wired into the thermocouple circuit to drive the movement upscale in the event of an open circuit. If so specified, bridge type TCB is furnished. With the thermocouple forming one leg of the bridge circuit, a break in the thermocouple or leadwire produces an unbalance causing the indicator to be driven upscale to shut off control power.

Note: Check to see that jumper wire on underside of chassis is attached to pin ST for models equipped with standard type TCB or to pin BR if bridge type TCB. Models are shipped as ordered, but because of interchangeability of chassis this should be verified.

Standard Type TCB	Although instruments equipped with standard TCB can be operated without TCB connected, its use may be desirable on some applications to guard against overheating in the event of an open thermocouple The preferred method of connecting TCB is shown in Figure 5. Use extension leadwire as required to make the connections between the instrument TC terminals and the thermocouple head. Use copper wire to connect

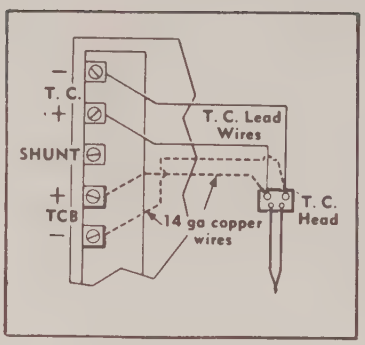


Figure 10

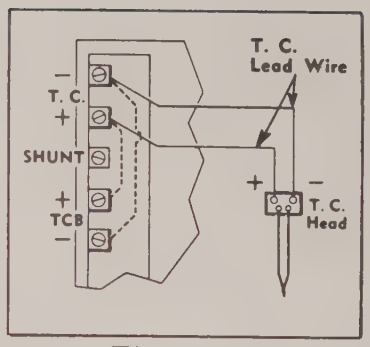


Figure 11

the TCB terminals to the thermocouple head, observing polarity. Wiring for TCB may be run in the same conduit with thermocouple leadwire. After connections are made, check for any error of indicator reading that may have resulted.

Although not recommended, an optional method of connecting TCB is to use jumpers at the instrument terminals as shown in Figure 11. As the length of leadwire used affects the amount of TCB compensation required, it is suggested that this method be used only with short leadwire lengths, 10 feet or less, and that the amount of TCB error be checked.

Standard Type TCB (continued)

To check for TCB operation, disconnect the thermocouple to simulate a broken thermocouple but leave the TCB wires connected to the leadwire. When the instrument is powered, the indicator should move upscale above the control set pointer to a position beyond the proportional band for zero output. No power would then be applied to the load. To check for TCB error, reconnect the thermocouple, power the instrument and read the temperature with the hot junction of the thermocouple held at a steady temperature. Then disconnect the wires at the TCB terminals, and note if the indicated temperature decreases. Reconnect to see if indicated temperature increases. If a shift in reading is noticed, adjust the screw on top of the plastic cover so that the reading with TCB powered is at the same point as read with TCB disconnected. If an adjustment is made, the ambient reading will also be shifted downscale.

Note: Adjustment should be made for correct ambient temperature reading before this check is made. See section on "Cold Junction Compensation".

If the instrument is equipped with bridge type thermocouple break protection, the need for any external TCB wiring is eliminated. See Figure 7.

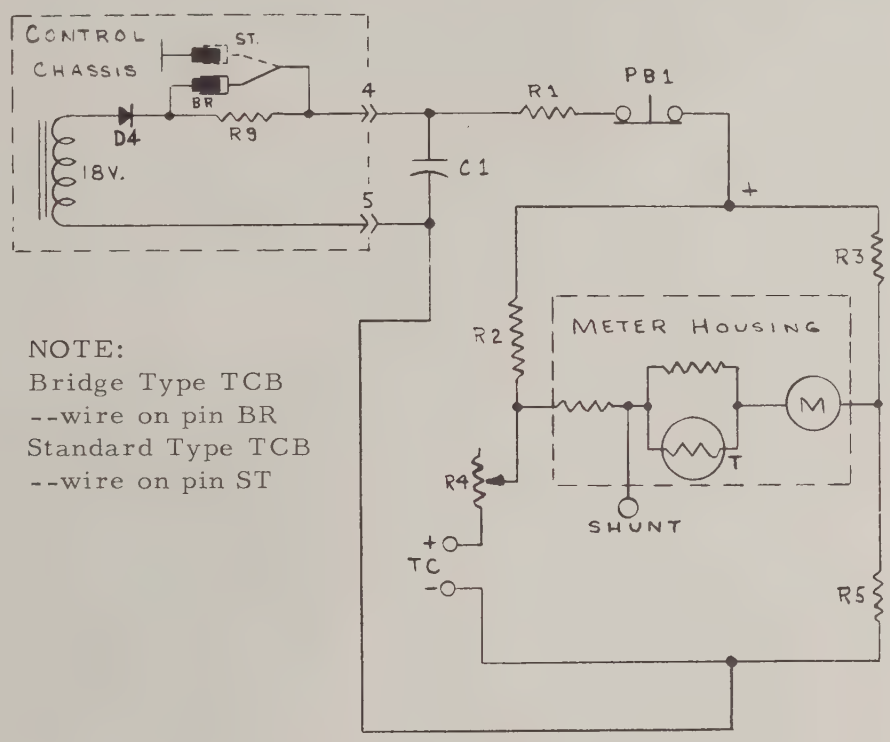


Figure 7

Bridge Type TCB

Bridge type TCB, when properly adjusted, eliminates the error that occurs with other types of TCB circuits. It also compensates for the thermocouple and leadwire resistance, as discussed in the section below. Adjustment is made in the following manner:

Remove the lower front cover, revealing the left-hand terminal strip and the push button over the words "TCB ADJ" with the adjustable potentiometer underneath. With the thermocouple connected and maintained at a steady or fixed temperature, and with the instrument powered, depress the push button and note the meter indicator reading. Then release the push button again and note the indicator reading. If there is a difference between the two readings, adjust the potentiometer with a screwdriver, with the push button released, until the meter indicator reading is the same as the initial reading when the push button was depressed. The proper adjustment is obtained when there is no discernable difference in meter readings with the push button depressed or released.

Bridge Type TCB (cont'd)	To check for TCB operation, disconnect one of the thermocouple wires to simulate a broken thermocouple. With the instrument powered, TCB is functioning properly if the meter indicator is driven upscale above the control set pointer causing the power to the load to be turned off.

TCB, either standard or bridge type, cannot be used with ratiation detectors or the Series 350 Reference Voltage Source. An instrument with standard TCB requires only that TCB connections not be made. If instrument was purchased equipped with bridge type TCB, and it is later desired to convert for these applications, please consult your Barber-Colman field office.

Thermocouple and Leadwire Resistance Compensation

Standard Type TCB	The external resistance, for which the meter has been calibrated and as marked on the scale, is the combined resistance of the leadwire and thermocouple. Meters equipped for standard thermocouple break protection are usually calibrated for 15 ohms (Ext.Res.15 ohms) which is greater than the combined resistance of most thermocouples plus leadwire used. The balance of the resistance, 15 ohms minus the actual external resistance, is inserted on a removable resistance strip located just under the meter section. The resistance value is marked on the strip and is inserted at the time of the original order. Other values are available.
Bridge Type TCB	Instruments equipped with the bridge type TCB circuit are normally calibrated for 25 ohms which allows up to 20 ohms for the external thermocouple and leadwire resistance. An adjustable potentiometer (R4), located on the left terminal strip inside the lower compartment, is used to compensate for the difference in resistance between the allowable 20 ohms and the actual thermocouple plus leadwire resistance. The proper adjustment of this potentiometer also eliminates any TCB error. See page 9 for adjustment procedure.

Cold Junction Compensation

For measuring temperature, thermocouples are the most commonly used sensing devices. They produce a voltage when there is a temperature difference between the "hot" or measuring junction and the "cold" junction located in the meter assembly. Since the difference in temperature between the hot and cold junctions determines the amount of millivoltage produced, it is necessary to keep the cold junction temperature constant, or to compensate for any changes that occur at this point. Compensation for temperature changes at the cold junction is accomplished either

mechanically or electrically, depending on model variation. Mechanical cold junction compensation, employing a bi-metallic strip, is furnished as standard on non-suppressed range instruments unless otherwise specified. Electrical cold junction compensation is usually provided with suppressed range instruments and can be supplied with any instruments that have bridge type TCB. See Figure 8.

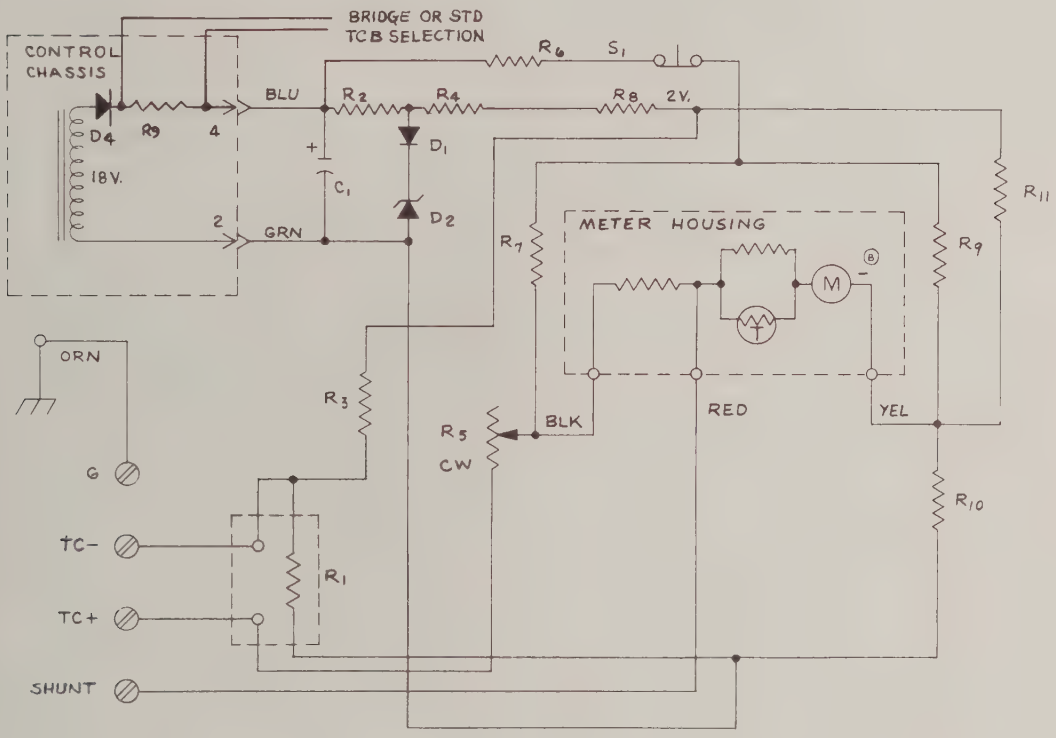


Figure 8

Notes:

1. Electrical cold junction compensation is accomplished by utilizing the resistance change, due to temperature, of resistor R1. Value depends on type of thermocouple used.

2. With electrical cold junction and suppression, value of R10 depends on the type of thermocouple and the amount of suppression desired.

Standard or Bridge TCB with Mechanical Cold Junction

After the instrument has been mounted, the cold junction reading of the meter should be checked. If the instrument is standard (i.e., with mechanical compensation), the cold junction check is made in the following manner:

Disconnect power leads and TC leadwire at the instrument. The indicator should come to rest at the ambient temperature of the meter; it is not supposed to read zero. Place a thermometer at the TC instrument terminals to read ambient temperature.

If the pointer does not indicate the ambient temperature, slowly adjust the screw located on top of the meter cover until it does. Because cold junction compensation is automatic, further corrections for changes in the ambient temperature need not be made.

Bridge TCB with Electrical Cold Junction

If the instrument has a non-suppressed range but is equipped with the electrical cold junction feature and bridge type TCB, check for proper cold junction adjustment according to the following:

The meter indicator should read zero when the instrument is unpowered. If the meter is not at zero, adjust the screw located on top of the meter cover until zero is obtained. Connect a jumper wire between TC- and TC+ and with the instrument powered, adjust the TCB potentiometer so no indicator movement occurs when the TCB push button is depressed and released. Place a thermometer at the TC instrument terminals to measure the ambient temperature reading. With the instrument still powered, the meter indicator reading should be the same as the ambient temperature reading. Further adjustments are not required because of the automatic electrical cold junction compensation.

For instruments with a suppressed range using electrical cold junction compensation:

The meter indicator should come to rest at the lowest temperature reading on the scale when the instrument is unpowered. If it does not, slowly adjust the screw located on top of the meter cover until it does. The meter is then properly adjusted and needs no further adjustment because of automatic electrical cold junction compensation.

OPERATION

Control Action

The control set pointer is adjustable by use of the knob located just below the indicating scale. The indicating pointer will move to indicate the temperature at the thermocouple. When the red signal light glows, the instrument is powered and the light will remain on until the power is turned off to the instrument. A d-c voltmeter connected across the test jacks will read zero when the circuit is in balance. Depending on the position of the indicating pointer, with respect to the control set point, this voltage can go as high as ± 95 volts d-c.

Control Adjustments

Final control action adjustments should be made after the unit has been in operation 45 minutes and has obtained maximum stability.

The controls are accessible by removing the lower front cover which is easily removed by first loosening the two screws.

Proportional Band:

The proportional band (PB) adjustment is used to vary the proportional band from 0.5% to 5% of full scale. Turning the PB adjustment clockwise will decrease the PB, and counterclockwise will increase it. An adjustment of the proportional band may require a reset adjustment to realign the temperature pointer with the control set point.

Manual Reset:

The manual reset adjustment is located on the right front of the control chassis. Adjust CW to lower and CCW to raise the controlled temperature to align the two pointers after the temperature has leveled off at a steady value. A small adjustment will cause a noticeable shift of the proportioning band.

Start-Up Adjustments:

For initial start-up, set the proportioning adjustment at some arbitrary position toward maximum. Set the control set pointer at

coincidence with the indicating pointer. Observe the motor operator and adjust reset so the motor stops about at midpoint of its full travel. If it is not possible to observe the motor operator, a voltmeter may be used. Placed across terminals 4 and 6 of the Model 475P, the voltmeter reading will be approximately 3 volts a-c, or across 5 and 6 will be approximately 8 volts a-c when the operator is at mid-position. The reading at the test jacks will be zero volts when circuit is balanced.

Do not make any further adjustments until the temperature has had time to level off to a steady value. For final adjustment, narrow the proportioning band until the temperature cycles, then back off CCW until cycling is no longer present.

Reset adjustment provides a means of aligning the meter indicator with the control set pointer to correct for offset. If the meter indicator does not coincide with the control set pointer after the controlled load has become thermally stable, an alignment adjustment should be made. Use a small screwdriver to reposition the reset adjustment capacitor. Turning the reset adjustment counterclockwise will shift the meter downscale so as to produce a lower temperature. Conversely, turning the reset adjustment clockwise will shift the meter indicator upscale, producing a greater temperature. The reset adjustment should be in small increments with sufficient time allowed after each adjustment to permit the controlled load to again become thermally stable. The proper reset adjustment occurs when the meter indicator coincides with the control set pointer when the load is thermally stable.

Routine Servicing

Servicing of the instrument, in the usual sense, is not required. It is recommended, however, to make routine checks of the condition of the thermocouple, extension wire and power connections. Meter accuracy may be verified from time to time. The frequency of these checks may vary from one month to three months, depending on the extent of usage, accuracy required and the seriousness of any problems that may be created due to possible "down time".

Spare parts for emergency servicing should be kept on hand. Where a number of instruments are located together, the plug-in parts are interchangeable to allow minimum inventory.

When trouble is encountered, the serviceman should familiarize himself with the process and instrument application to determine the exact function of the instrument as applied. The instrument trouble usually can be traced to two basic problems: measurement or control.

Measurement or Control Trouble

Measurement trouble can be detected by observing the pointer position. If the measured temperature is known to be in error, check the following:

1. Open or broken thermocouple, leadwire or connector. Check visually or with a volt-ohmmeter.

2. Deteriorated thermocouple. Compare reading with a test thermocouple or check output with a Barber-Colman portable potentiometer.

3. In most applications the thermocouple is grounded through the furnace or machine to which it is attached. If this is not the case, run a wire from TC- to the ground terminal on the left-hand terminal strip and ascertain that the instrument is also grounded.

   Note: In case the thermocouple is directly in contact with a heater or similar electrical load, a 2 mfd, 200 volt capacitor should be connected between terminal TC- and ground.

4. Accidental shorts, grounds or moisture in the leadwire (especially with asbestos type insulation).

5. High resistance in leads due to loose connectors, poor splicing, dirty switch contacts, and other faulty connectors.

6. Problems caused by vibration or shock.

7. Meter accuracy. This can be checked with a Model 330P portable potentiometer.

8. Errors due to oil and grease. Do not oil or grease any part of the instrument.

9. Incorrect cold junction (ambient) setting. The correctness of this setting should be checked following any other meter servicing.

10. Incorrect TCB adjustment (see section on "Thermocouple Break Protection").

Control trouble may be detected by observing control point and indicator pointer position. If control action does not occur at control point, do the following:

1. Check electrical connectors and correctness of line voltage. Ascertain as to whether trouble is internal or external to the instrument.

2. Adjust manual reset as described on page 14.

3. If the instrument does not operate (i.e., red light does not glow), make sure the meter indicator is downscale from the control set point and turn the reset adjustment through its entire adjusting range. If the instrument then turns on, let the controlled load stabilize, after which proper reset adjustment can be made as described under "Control Adjustments". If the instrument does not turn on, further servicing or replacement of the control chassis is suggested.

Calibration Check

The instrument has been calibrated at the factory to the specified limits of accuracy. No further adjustment need be made. If, however, it is later decided to check the calibration, obtain a Barber-Colman Model 330P Portable Potentiometer, or its equivalent, and perform the following:

Standard TCB Mechanical Cold Junction	If instrument is equipped with standard TCB and mechanical cold junction compensation: Follow directions outlined in the Model 330P Instruction Manual on page 11.

Bridge TCB with Mechanical or Electrical Cold Junction

If instrument is equipped with bridge type TCB:

Remove the TC wire and short out the TC terminals by connecting a jumper wire between terminals marked TC- and TC+. Then, with the instrument powered, adjust the TCB potentiometer so no meter indicator movement occurs when the TCB push button is depressed and released. With the jumper wire then removed, and the instrument unpowered, connect a Barber-Colman 330P (or equivalent) to the thermocouple terminals and follow instructions stated below.

Bridge TCB with Mechanical Cold Junction

If instrument has mechanical cold junction compensation:

Procedure for calibrating is as outlined in the Model 330P Instruction Manual -- except that the Model 330P must be set for zero external resistance instead of the external resistance marked on the scale.

Bridge TCB with Electrical Cold Junction

If the instrument has electrical cold junction compensation and a non-suppressed range:

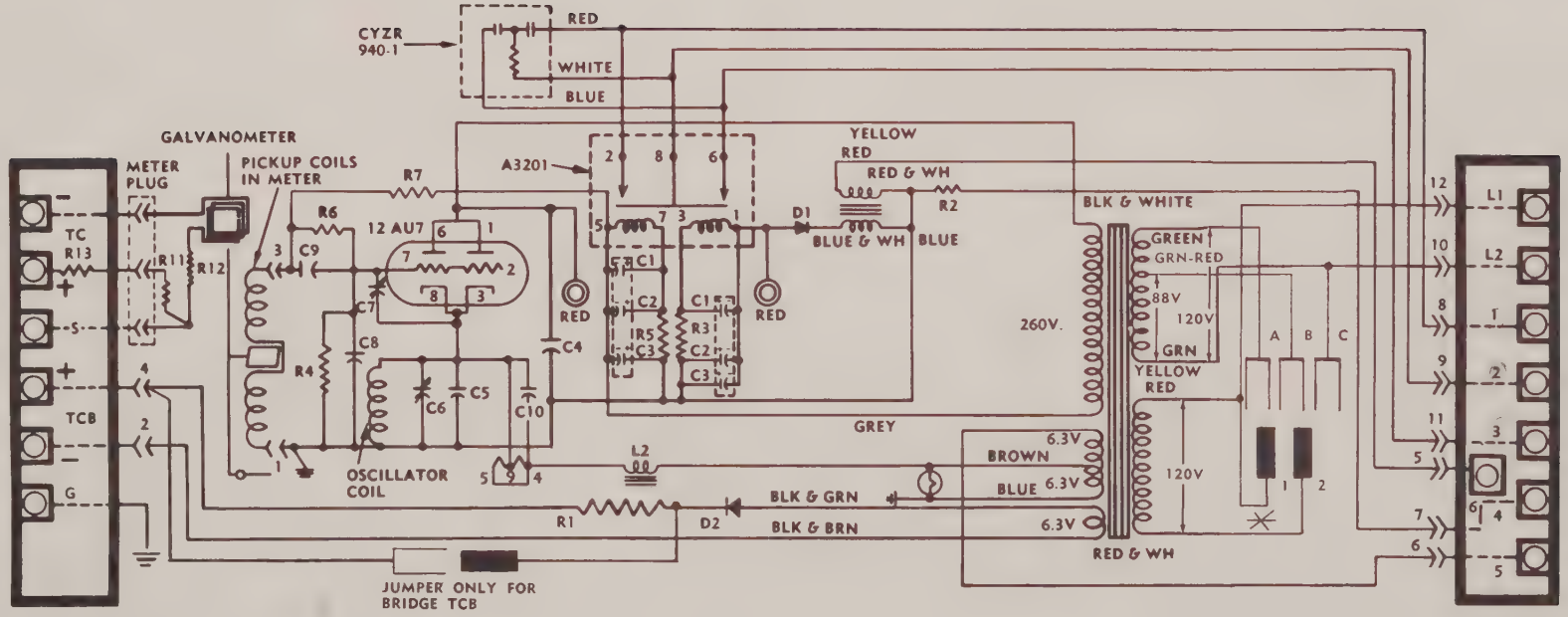
Calibrating procedure is as outlined in the Model 330P Instruction Manual except for the following: The Model 330P must be set for zero external resistance, and for a zero cold junction setting instead of ambient. Since most thermocouple tables are based on 32°F reference temperature, the 0°F millivoltage equivalent has to be added (algebrically) to the desired temperature millivoltage equivalent. For example, the proper 400°F I/C setting on the potentiometer would be:

(0°F) = -0.89 mv, and 400°F = 11.03 mv

11.03 - (-0.89) = 11.92 mv, which is the proper setting

Suppressed range instruments:

These models require a special procedure for calibrating the instrument. Contact your Barber-Colman field office if a calibration check is believed to be necessary.



)) Indicates Plug Pins On Chassis

◎ Test Jacks

✳ For 120 v connect A to 1 and C to 2.
For 208 v connect B to 2.
For 240 v connect A to 2.

CHASSIS SOCKET IN COMPARTMENT

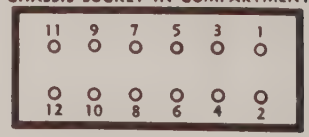
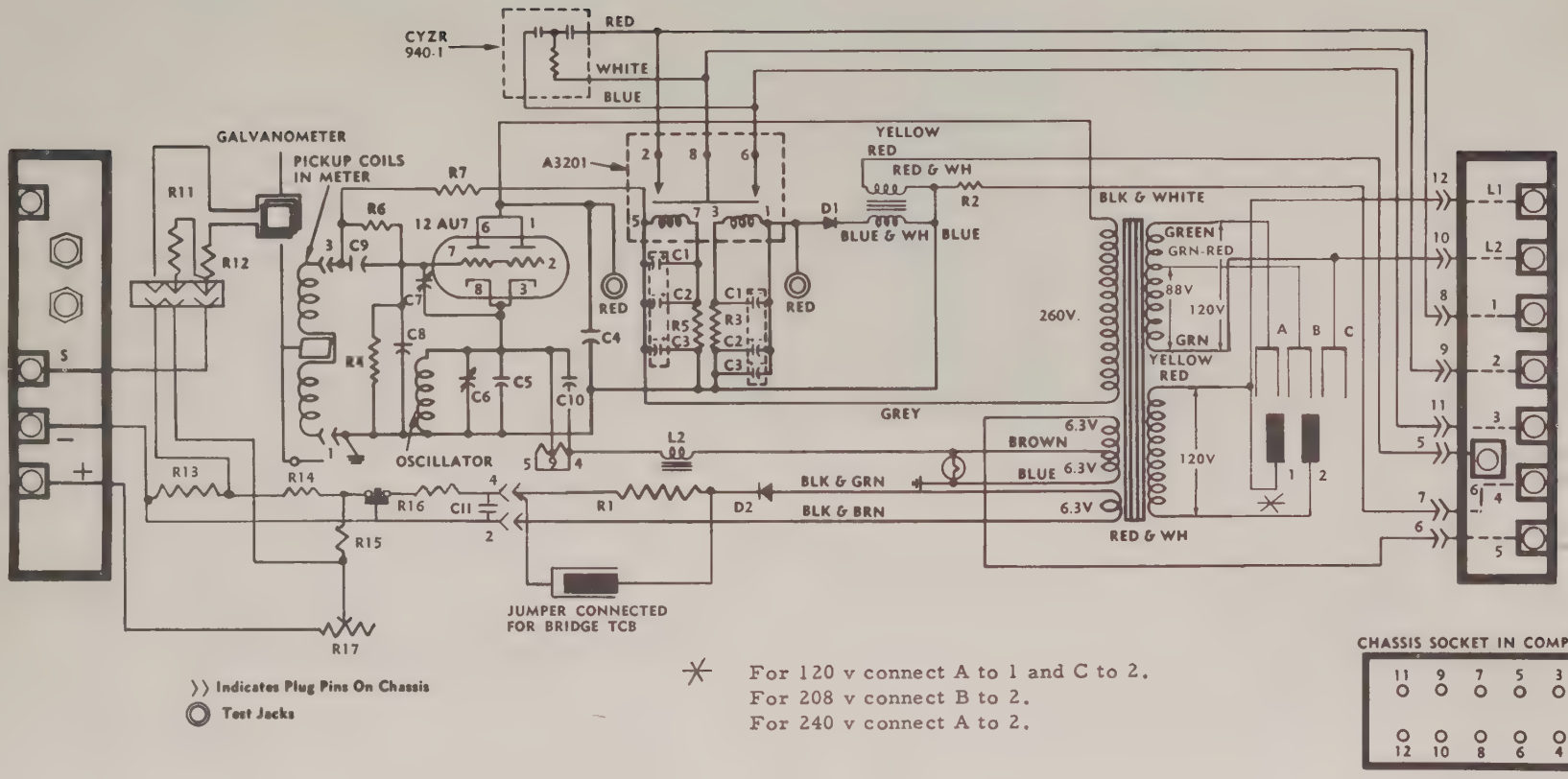


Figure 9

Internal Wiring Diagram
Model 475P with Standard TCB



)) Indicates Plug Pins On Chassis

Test Jacks

✳ For 120 v connect A to 1 and C to 2.
For 208 v connect B to 2.
For 240 v connect A to 2.

Internal Wiring Diagram
Model 475P with Bridge Type TCB

REPLACEMENT PARTS LIST

Electronic Components

Model 475P with Standard or Bridge Type TCB

Item	Part Number	Description
C1, C3	39-106	20 mfd Capacitor
C2		40 mfd Capacitor
C4	39-172	.005 mfd Capacitor
C5	39-123	91 mmf Capacitor
C6	39-105	8-50 mmf Variable Capacitor
C7	39-161	3-35 mmf Variable Capacitor
C8	39-185	15 mmf Variable Capacitor
C9	39-62	.02 mfd Capacitor
C10	39-63	.001 mfd Capacitor
D1	37-66	Rectifier
D2	37-30	Rectifier
L1	41-120-1	Oscillator Coil
L2	41-124	Filament Coil
R1	CYZR 170-9	88 k Resistor
R2	40-106	30 Ω ± 5% PW-5 Resistor
R3	40-113	3.3 k ± 5% 1 w Resistor
R4	40-62	2.2 k Resistor
R5	40-44	3.3 k Resistor
R6	CYZR 170-18	4.7 meg Resistor
R7	40-89	8.2 meg Resistor
R11		Thermocouple Range Multiplier
R12	A-3049-1	Temperature Compensator Resistor
T1	30-148	Transformer
T2	30-82	Transformer

Model 475P with Standard TCB Only

Item	Part Number	Description
R18	A-3497	External Resistance Compensator

Model 475P with Bridge Type TCB Only

R13	CYZR 326-103	5 Ω Resistor
R14	CYZR 326-54	2.5 k Resistor
R15	40-162	10 k Resistor
R16	40-70-2	47 k Resistor
R17	29-133	25 Ω Resistor
C11	39-68	39 mmf Capacitor

Suggested Replacement Parts to Keep on Hand

Quantity	Part Description	Part Number
1	MAZDA Pilot Lamp	36-22-1
1	Electronic Tube 12AU7	EYZP-70-9
1	Replacement Thermocouple	Barber-Colman can supply thermocouple assemblies, components or wire for any requirement you may have. If need be, delivery will be made in 48 hours. Contact your nearest Barber-Colman field office.
1	Indicating Meter Assembly	A-6175
1	Control Chassis	A-6023

We do not recommend electronic component replacement except by well equipped instrument repair shops.

Barber-Colman, Industrial Instruments Division, maintains service and repair facilities in many major cities in the United States and Canada. Consult your yellow page directory.

DEFINITION OF TERMS

CONTROL SET POINT	The position on the instrument scale to which the control point setting mechanism is set.
CONTROLLED VARIABLE	That quantity or condition which is varied by the controller so as to affect the power of the measured variable. Example: Power to an electric furnace.
CYCLING	A periodic change of the measured variable from one value to another. Oscillation and hunting are synonymous terms.
FINAL CONTROL ELEMENT	That portion of a control system which directly changes the value of the controlled variable. Example: Model 621A Power Controller.
MEASURED VARIABLE	That quantity or condition which is measured and regulated through control of the controlled variable. Example: Temperature in a furnace.
OFFSET	A sustained deviation from control point due to proportional control action. It is the difference existing at any time between control point and the actual value of the measured variable. Droop is a synonymous term.
OSCILLATION	See Cycling.
PROPORTIONAL BAND	That change in value of the measured variable that is necessary to cause full travel of the final control element. It is measured as a percent of full scale span. Throttling range is a synonymous term.
PROPORTIONAL CONTROL	Controller action in which there is a continuous linear relation between the value of the measured variable and the position of the final control element. In other words, the output of the controller is proportional to its input. Synonymous terms are throttling or modulating action.

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